CLAIMS

1. A method of implementing a wide limit mode (WLM) of operation in a vehicle comprising an energy storage system having a rechargeable battery, the battery having a plurality of monitored battery parameters, a discharge power limit and a closed-loop controller, the controller having a timer and a counter that are adapted to count time intervals associated with the implementation of the WLM by incrementing a count when the WLM is active and decrementing the count or maintaining a zero count when the WLM is not active, comprising the steps of:

(1) determining whether the WLM is active;

(2) setting a WLM discharge power limit when the WLM is active that is greater than the discharge power limit; and

(3) establishing a duty cycle for the WLM using the timer and counter, wherein the duty cycle comprises a maximum time interval during which the WLM discharge power is available for use by the vehicle and a minimum time interval during which the WLM discharge power is not available for use by the vehicle.

2. The method of claim 1, wherein determining whether WLM is active in step (1) is performed using a vehicle speed input and a vehicle torque command input.

3. The method of claim 2, comprising the further steps of:

(1a) determining a WLM output speed ratio (R_N) that characterizes the WLM as a function of the vehicle output speed input;

(1b) determining a WLM output torque ratio (R_T) that characterizes the WLM as a function of the vehicle output torque command input;

(1c) multiplying R_N and R_T to obtain a WLM ratio; wherein the WLM ratio (R_{WLM}) has a value which determines whether the WLM is active or not.

4. The method of claim 3, wherein R_N comprises a value in the range $-1 \leq R_N \leq 1$, R_T comprises a value in the range $-1 \leq R_T \leq 1$, and wherein WLM is active for values of R_{WLM}, where $0 < R_{WLM} \leq 1$, and WLM is not active for all other values of R_{WLM}.

5. The method of claim 4, wherein the value of R_N as a function of vehicle speed and the value of R_T as a function of the torque command input are determined from a look-up table.

6. The method of claim 1, wherein setting the WLM discharge power limit of step (2) comprises shifting the discharge power limit by an amount that is determined by imputing a change in at least one parametric battery discharge power limit as a function of at least one battery parameter

7. The method of claim 6, comprising the further steps of:

(2a) shifting the monitored value of at least one of the monitored battery power parameters (B_1) to a lower value (B_2); and

(2b) shifting the parametric battery power discharge limit (P_1) associated with B_1 to an increased value associated with a shifted parametric battery power discharge limit (P_2) in accordance with a parametric relationship between the at least one parameter and the parametric battery power discharge limit.

8. The method of claim 7, wherein the amount by which the at least one parametric discharge power limit is increased and the value of the WLM discharge power limit are directly proportional to the value of R_{WLM}.

9. The method of claim 8, wherein the plurality of battery power parameters are selected from the group consisting of a battery temperature, battery state of charge and battery amp-hour throughput.

10. The method of claim 1, wherein step (3) comprises the further steps of:

(3a) incrementing the value of the count (C) by an increment associated with a control loop;

(3b) determining the value of C and whether WLM is active, wherein if C is less than a WLM maximum count limit (C_M) and WLM is active, returning to step (1), and wherein if C is equal to C_M or WLM is not active, proceeding to step (3c);

(3c) setting the discharge power limit;

(3d) decrementing the value of C by a decrement associated with a control loop;

(3e) determining the value of C and whether WLM is active; wherein if the count is greater than a WLM dead band limit (C_{DB}) and WLM is active or not active, returning to step (3c); and wherein if the count is less than or equal to C_{DB} and greater than zero and WLM is not active, returning to step (3c); and wherein if the count is less than or equal to C_{DB} and greater than or equal to zero and WLM is active, returning to step (1); and wherein if the count is equal to zero and WLM is inactive, proceeding to step (3f);

(3f) holding the count at zero until WLM is active, and then returning to step (1).

11. A control algorithm for implementing a wide limit mode (WLM) of operation in a vehicle comprising an energy storage system having a rechargeable battery, the battery having at least one monitored battery power parameter, at least one parametric discharge power limit and a closed-loop controller operating through the execution of a plurality of control loops and adapted to determine whether the WLM is active or not active, the controller having a timer and a counter that are adapted to count time intervals associated with the implementation of the WLM by incrementing a count when the WLM is active and decrementing the count or maintaining a zero count when the WLM is not active; comprising the steps of:

(1) determining a WLM ratio using a vehicle speed input and a vehicle torque command input;

(2) initializing the timer, counter and a control loop, wherein the WLM ratio is set to zero for the first control loop ;

(3) determining whether the WLM is active and whether the timer is expired, and if the WLM is active and the timer is not expired, proceeding to step (4), otherwise, proceeding to step (5);

(4) incrementing the timer and counter and proceeding to step (8);

(5) setting the WLM ratio to zero;

(6) decrementing the timer and counter and proceeding to step (7);

(7) setting a lower limit for the counter and proceeding to step (8);

(8) determining the amount of a WLM discharge power limit shift that is based on the WLM ratio;

(9) applying the WLM discharge power limit shift to at least one parametric discharge power limit; and

(10) determining whether the control loop is the last control loop, wherein if the control loop is the final control loop, and if yes, ending the algorithm, and if no, iterating the algorithm for another control loop by returning to step (1).

12. The method of claim 11, wherein calculating a WLM ratio using a vehicle speed input and a vehicle torque command input comprises the further steps of:

(1a) determining a WLM speed ratio (R_N) that characterizes the WLM as a function of the vehicle speed input;

(1b) determining a WLM torque ratio (R_T) that characterizes the WLM as a function of the vehicle torque command input;

(1c) multiplying R_N and R_T to obtain a WLM ratio (R_{WLM}); wherein the WLM ratio has a value which determines whether the WLM is active.

13. The method of claim 12, wherein R_N comprises a value in the range $-1 \leq R_N \leq 1$, R_T comprises a value in the range $-1 \leq R_T \leq 1$, and wherein

WLM is active for values of R_{WLM}, where $0 < R_{WLM} \leq 1$, and WLM is not active for all other values of R_{WLM}

14. The method of claim 13, wherein the value of R_N as a function of the vehicle speed and the value of R_T as a function of the torque command input are determined from a look-up table.

15. The method of claim 11, wherein the step of determining the amount of a WLM discharge power limit shift comprises imputing a change in at least one parametric battery discharge power limit as a function of at least one monitored battery power parameter.

16. The method of claim 15, comprising the further steps of:

(8a) shifting the monitored value of at least one of the monitored battery power parameters (B_1) to a lower value (B_2); and

(8b) shifting the parametric battery power discharge limit (P_1) associated with B_1 to an increased value associated with a shifted parametric battery power discharge limit (P_2) in accordance with a parametric relationship between the at least one parameter and the parametric battery power discharge limit.

17. The method of claim 16, wherein the amount by which the at least one parametric discharge power limit is increased and the value of the WLM discharge power limit are directly proportional to the value of R_{WLM}.

18. The method of claim 17, wherein the plurality of battery power parameters are selected from the group consisting of a battery temperature, battery state of charge and battery amp-hour throughput.